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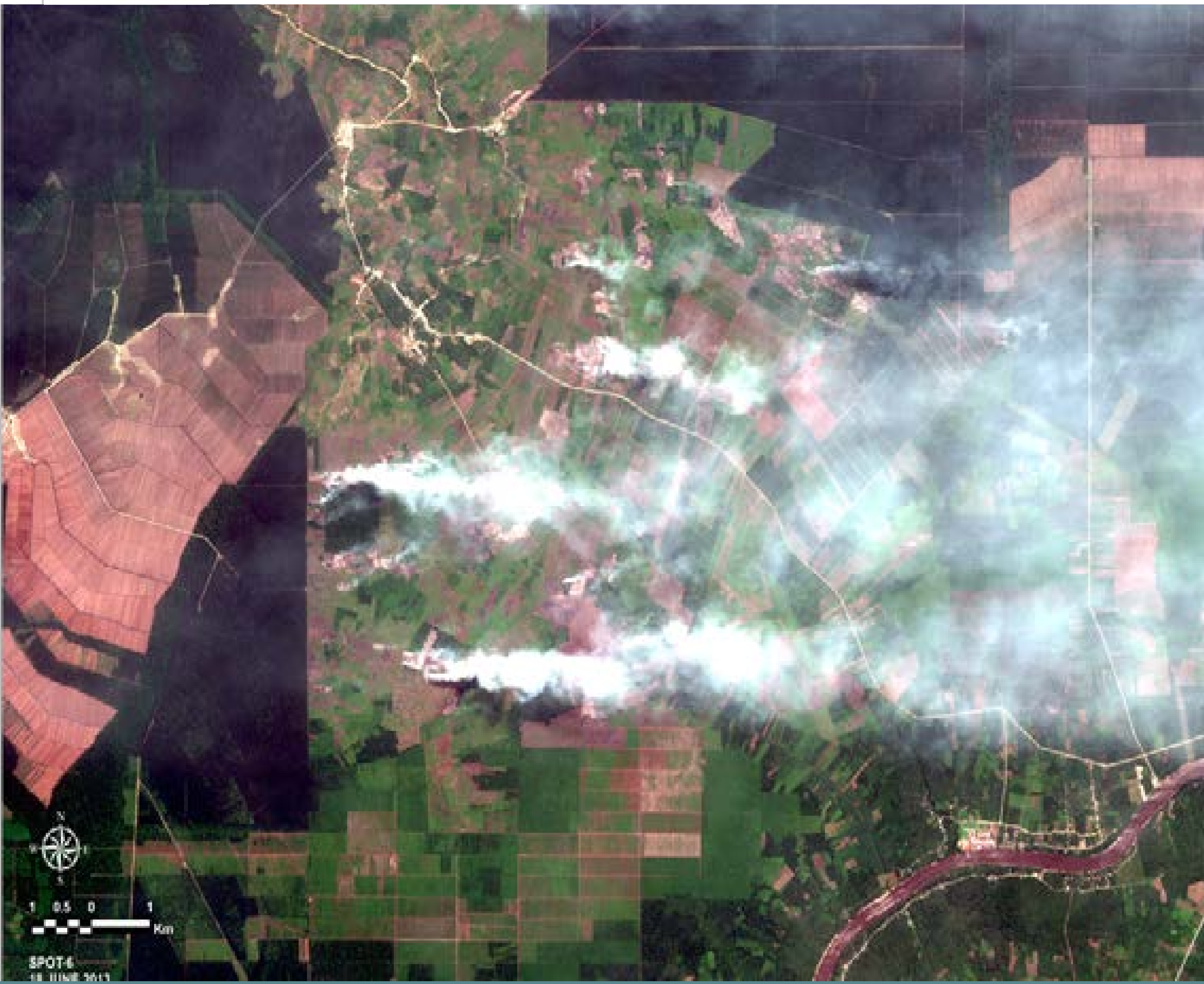

Effective use of space-based information to monitor disasters and its impacts

Lessons Learnt from Forest and Land Fires in Indonesia

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Effective use of space-based information to monitor disasters and its impacts

Lessons Learnt from Forest and Land Fires in Indonesia

Suwarsono - LAPAN

Parwati Sofan - LAPAN

Dr. M. Rokhis Khomarudin - LAPAN

Dr. Shirish Ravan - UNOOSA/UN-SPIDER

Contributors (from LAPAN):
Winanto
Taufik Maulana
Yenni Vetrita
Any Zubaidah
M. Priyatna
Kusumaning Ayu DS
Taufik Hidayat
Iskandar Effendi

Editing and booklet design by Hongmeng Liu and Nicole Ho Yan Lau

About UN-SPIDER

www.un-spider.org

In its resolution 61/110 of 14 December 2006 the United Nations General Assembly agreed to establish the "United Nations Platform for Space-based Information for Disaster Management and Emergency Response - UN-SPIDER" as a new United Nations programme, with the following mission statement: "Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle."

UN-SPIDER aims at providing universal access to all types of space-based information and services relevant to disaster management by being a gateway to space-based information for disaster management support; serving as a bridge to connect the disaster management and space communities; and being a facilitator of capacity building and institutional strengthening.

Whereas there have been a number of initiatives in recent years that have contributed to making space technologies available for humanitarian and emergency response, UN-SPIDER is the first to focus on the need to ensure access to and use of such solutions during all phases of the disaster management cycle, including the risk reduction phase, which contributes significantly to reducing the loss of lives and property.

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Acronyms

AVHRR	Advanced Very High Resolution Radiometer
ATSR	Along Track Scanning Radiometer
BAI	Burned Area Index
BNPB	Badan Nasional Penanggulangan Bencana
BUI	Buildup Index
DC	Drought Code
DMC	Duff Moisture Code
DNBR	Differenced NBR
ENSO	El Nino-Southern Oscillation
ESA	European Space Agency
FFMC	Fine Fuel Moisture Code
FDRS	Fire Danger Rating System
FWI	Fire Weather Index
GIS	Geographic Information System
HANDS	Hotspot and NDVII Differencing Synergy
ISI	Initial Spread Index
LAPAN	Indonesian National Institute of Aeronautics and Space
MODIS	Moderate Resolution Imaging Spectroradiometer
MISR	Multi-angle Imaging SpectroRadiometer
NASA	National Aeronautics and Space Administration
NBR	Normalized Burn Ratio

NDMA	National Disaster Management Agency
NOAA	National Oceanic and Atmospheric Administration
NIR	Near-Infrared
NDVI	Normalized Difference Vegetation Index
RGB	Red, Green, Blue
SWIR	Shortwave-Infrared Reflectance
UNOOSA	United Nations Office for Outer Space Affairs
UN-SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response

Foreword

The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) was established in 2006 by the United Nations General Assembly in its resolution 61/110. It is a program implemented by the United Nations Office for Outer Space Affairs (UNOOSA). UN-SPIDER aims to ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle.

One of the main tasks of UN-SPIDER is knowledge management and transfer. This publication is prepared as one of the main forms of support for the exchange of knowledge about the application of remote sensing for forest and land fire monitoring. This publication will be incorporated into the UN-SPIDER Knowledge Portal (www.un-spider.org), a web-based platform for information, communication and process support and fosters the exchange of information for sharing experiences, capacity-building and Technical Advisory Support.

Forest and land fire has become a serious threat to global communities for the last two decades, especially related to the aspects of environments and natural resources degradation. In Indonesia region, especially Sumatera (Sumatra) and Kalimantan, almost every year, thousands of hectares of forest and lands are consumed by wildfire resulting in loss of property with significant economic costs and environmental impacts. The phenomena is related to land utilization patterns and deforestation. Land and forest fires can be detected, identified, monitored and mapped by using satellite images.

Forest fire in peatlands, Central Kalimantan, September 18, 2014

This booklet contains some applications of remote sensing for forest and land fires monitoring which includes fire hotspot monitoring, smoke and haze monitoring, burned area mapping and fire danger rating systems. Several scientific publications relating to the use of remote sensing for monitoring forest and land fires are referred while preparing this booklet. The images used in the booklet are the results of a work carried out in LAPAN.

Special acknowledgement to all contributors in the preparation of this publication.

Dr. M. Rokhis Khomarudin

Director, Remote Sensing Application Center, Indonesian National Institute of Aeronautics and Space (LAPAN)

1. Forest/Land Fires in Indonesia and El Niño Southern Oscillation

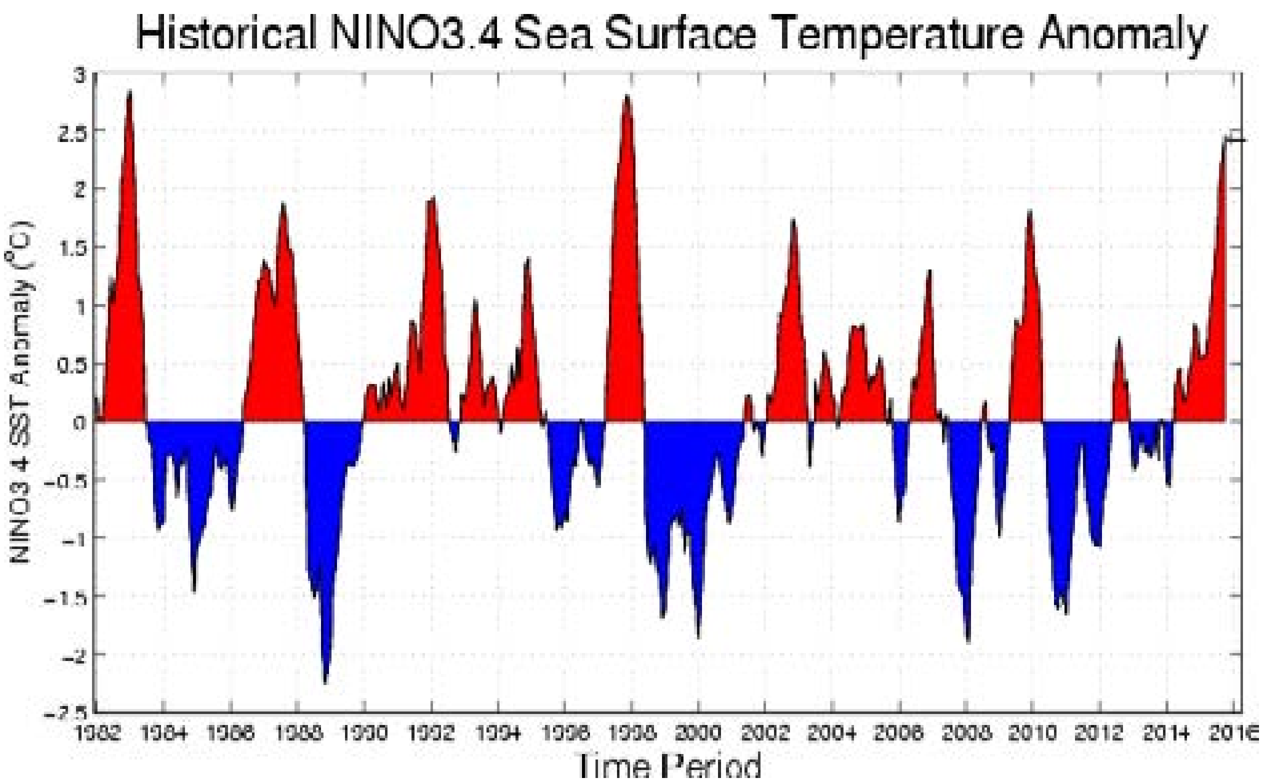
Forest/land fires is a major source of concern for both environmental, public health and safety reasons in many parts of the world. This is due to the fact that they cause casualties as well as important economic, social and environmental losses. These events play an important role in global climate change as they are responsible for a significant amount of greenhouse gases, particulates and aerosol emissions into the atmosphere (Merino et al., 2008). Throughout the world, forest/land fires are also a cause of deforestation, land clearing, grassland management, pest control and other agricultural applications. As a natural disturbance agent, forest/land fires not only work destructively but also as constructive power in terms of maintaining the health of ecosystems. Through the process of consumption of biomass, recycling nutrients and carbon, forest/land fires have strong impacts on the structure and functions of ecosystems and determine the secondary succession and restoration over time, especially for fire-prone ecosystems (Chen, 2006). For both purposes of fire management and facilitating post-fire restoration, it is essential to well understand forest/land fire characteristics and other relevant factors such as fire regime, meteorology, vegetation type, topography and the temporal and spatial scale of fire combustion. Space-based technologies can serve as an efficient and effective tool in this process.

Current estimates suggest that globally over 85% of fires occur in the equatorial and subtropical regions, primarily in Africa, South America and Southeast Asia. Much of this activity is concentrated in developing countries where extent of burning is not always adequately documented (Prins et al., 2002).

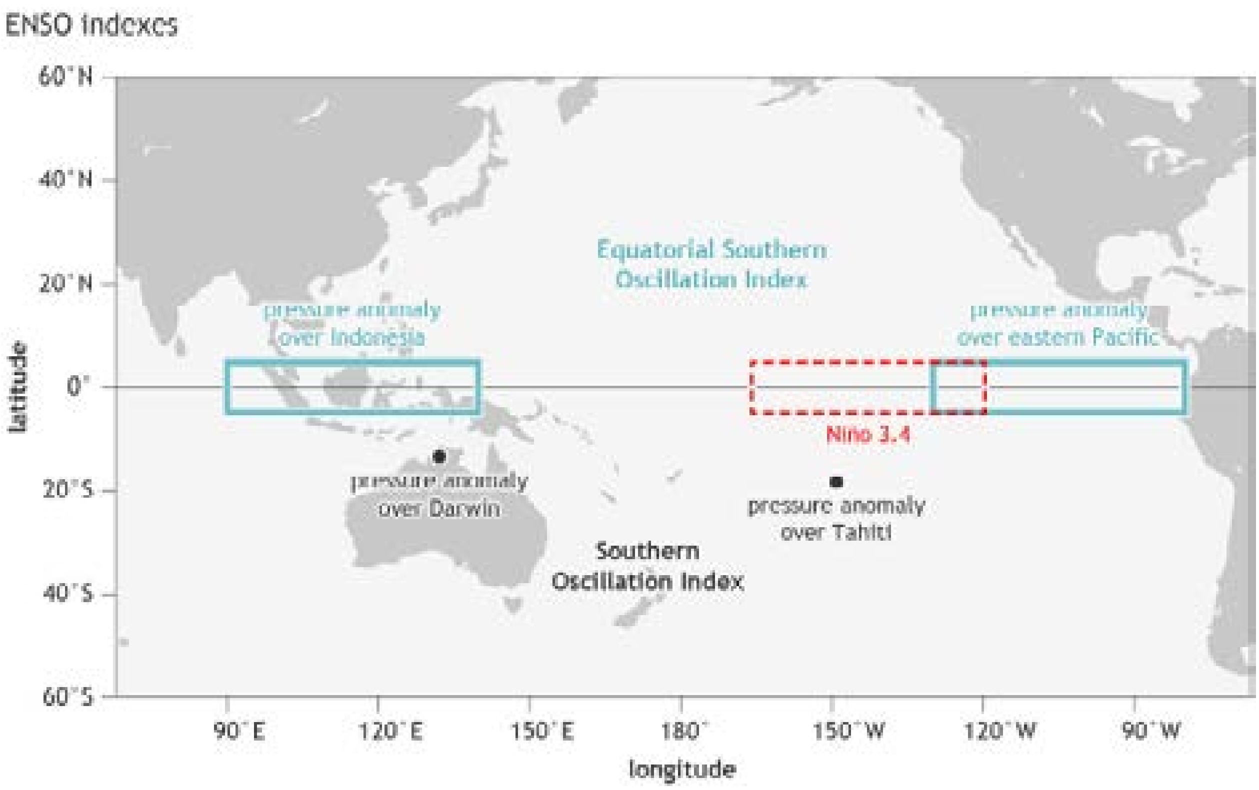
Fires in Indonesia occur especially in Sumatera and Kalimantan during the dry season months of June-September and are more frequent and severe during El Niño years due to a pronounced rainfall deficit (Chandra et al., 1998; Wooster et al., 1998; Kitaet al., 2000; Siegert and Hoffmann, 2000; Roswintiarti and Raman, 2003).

In 1982 - 1983, parts of the region were affected by large scale vegetation fires. This occurred due to interactions between land clearance activities and the abnormally dry weather conditions associated with the ongoing El Niño-Southern Oscillation (ENSO) event. During this earlier period, the largest uncontrolled forest/land fires currently documented reportedly damaged around 5 million hectares of primary and secondary rain forest on Borneo (Wooster & Strub, 2002).

A firefighter from the Ministry of Forestry of Indonesia, together with army, spray water into peat land forests, Riau September 9, 2015. Image: REUTERS



Historical sea surface temperature anomaly in Niño 3.4 (red colour refer to El Niño; blue colour refer to La Nina). Source: IRI



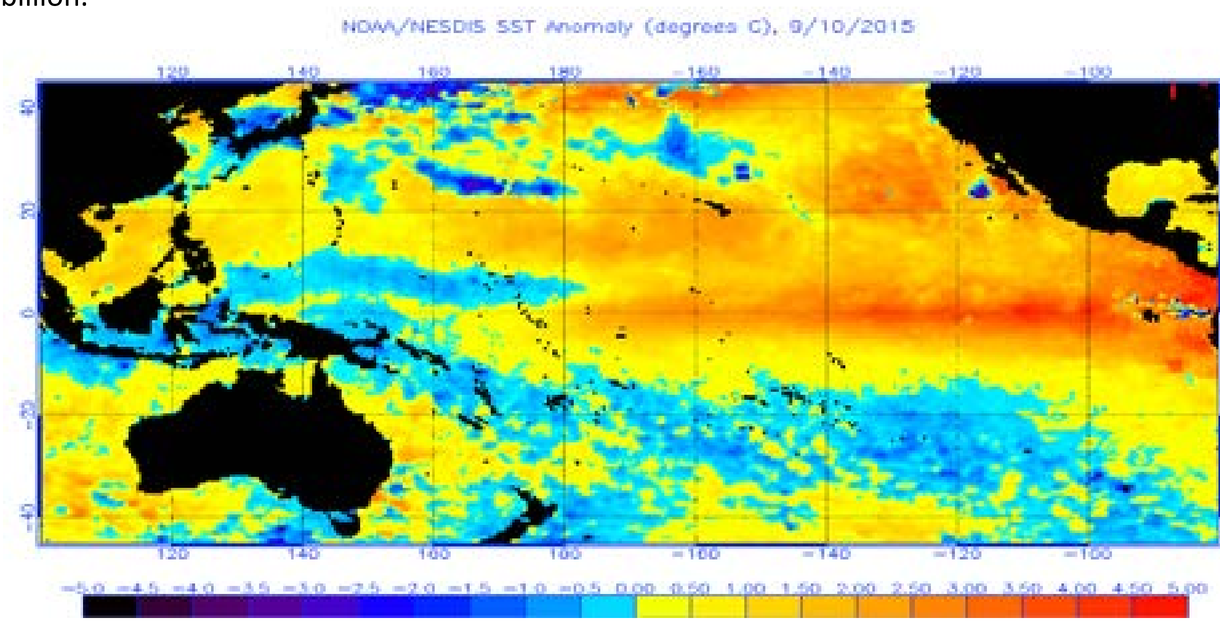
The Niño3.4 region in the east-central tropical Pacific Ocean for sea surface temperature (red dashed line). Source: NOAA Climate.gov

The 1997-1998 fires were apparently of a similar magnitude. The 1997-1998 fires generated an unprecedented off-site effect in terms of the thick smog that blanketed Sumatera and Borneo and neighbouring regions of Malaysia and Singapore. The total fire-affected land area during the 1997/1998 ENSO was about 9.75 million ha (BAPPENAS-ADB, 1999).The economic losses due to the 1997/98 fires that resulted in forest degradation and deforestation were estimated between $1.6 and 2.7 billion. While the smoke haze pollution costs were $674 - 799 million, and the carbon emissions costs were around $2.8 billion (Taconi, 2003).

President Joko Widodo checking the forest/land fires and haze in South Sumatera on September 7, 2015. Image: ANTARA

The strong El Niño has reoccurred in 2015. The sea surface temperature in Niño 3.4 region has increased during April to November 2015.The sea surface temperature in Indonesia region was lower than the normal temperature. There was almost no rainfall during September 2015. Severe fires occurred in the peat lands of Sumatera and Kalimantan. Haze problems existed around 2 months during September until October over Sumatera and Kalimantan regions of Indonesia and also other neighbouring countries. The social and economic activities were hampered over 2 months. The World Bank estimated the economic cost to be around $15 billion.

Students walking in front of school buildings shrouded in smog in Palangkaraya, Central Kalimantanon October 3, 2015. Image: ANTARA



The sea surface temperature anomaly on September 9, 2015. Source: NOAA NESDIS

2. Fire Danger Rating System

Fire Danger Rating System (FDRS) is a system for evaluating the fire environment (such as ease of ignition, rate of spread, difficulty of control and impact of fire) on regular intervals and in an objective way (de Groot et al., 2006).

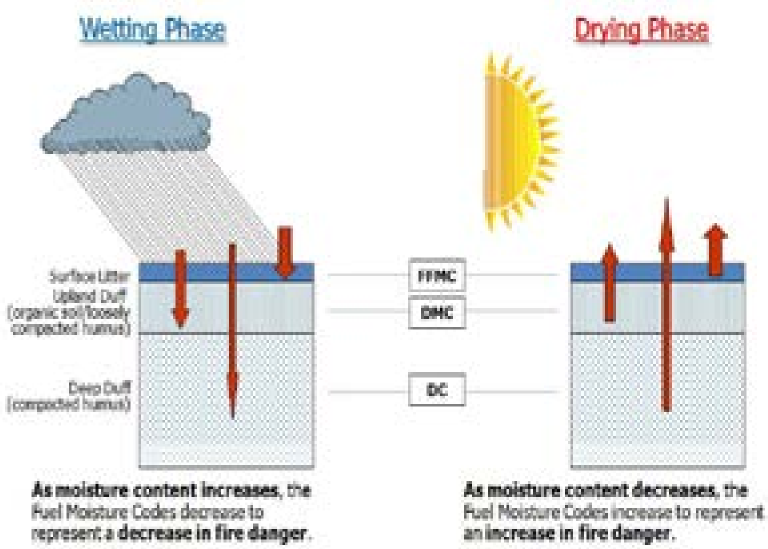
FDRS was developed from the Canadian Forest Fire Weather Index (FWI) System, and was adapted to other global regions, e.g., New Zealand, Florida, Fiji, Spain, Indonesia, Malaysia and South Africa.

FWI system evaluates fuel moisture content and relative fire behaviour by using the past and present effect of weather on forest floor fuels (de Groot et al., 2006).

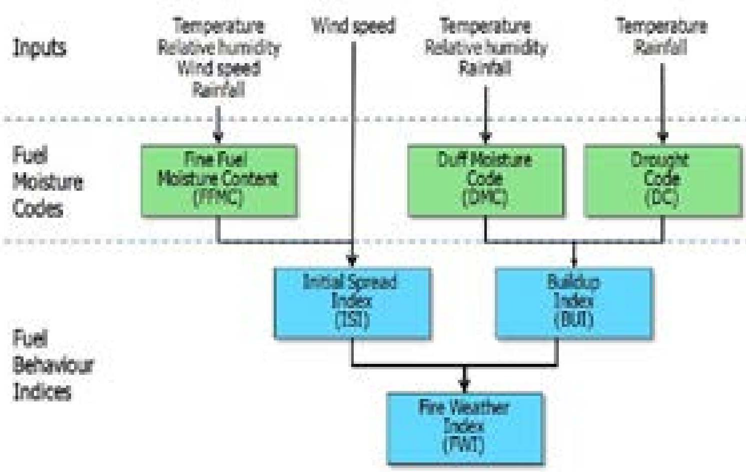
The FWI System components are calculated using daily temperature, relative humidity, wind speed and 24-hour rainfall data collected at 1200 Local Standard Time.

Refer to de Groot et al. (2006), the FWI System provides relative indicators of general fire danger across the landscape based on weather. It comprises three fuel moisture codes representing different layers in the forest floor and three fire behaviour indices:

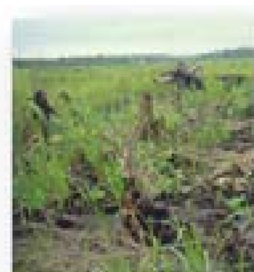
- Fine Fuel Moisture Code (FFMC), a numerical rating of the moisture content of surface litter and other cured fine fuels on the forest floor;



The Moisture Codes are an accounting method to keep track of moisture content through the wetting and drying phases in the fuel layers (Groot et al., 2006)



FWI System



- Duff Moisture Code (DMC), a numerical rating of the average moisture content of loosely compacted organic layers of moderate depth in the forest floor;

- Drought Code (DC), a numerical rating of the average moisture content of deep, compact organic layers in the forest floor;

Source of field images: Canadian Forest Services FWI Training Document

- Initial Spread Index (ISI), a numerical rating of the expected rate of fire spread;
- Buildup Index (BUI), a numerical rating of the total amount of fuel available for combustion; and
- FWI, a numerical rating of fire intensity that is used as a general indicator of fire danger.

The development of remotely-sensed FDRS for Western Indonesia was motivated by:

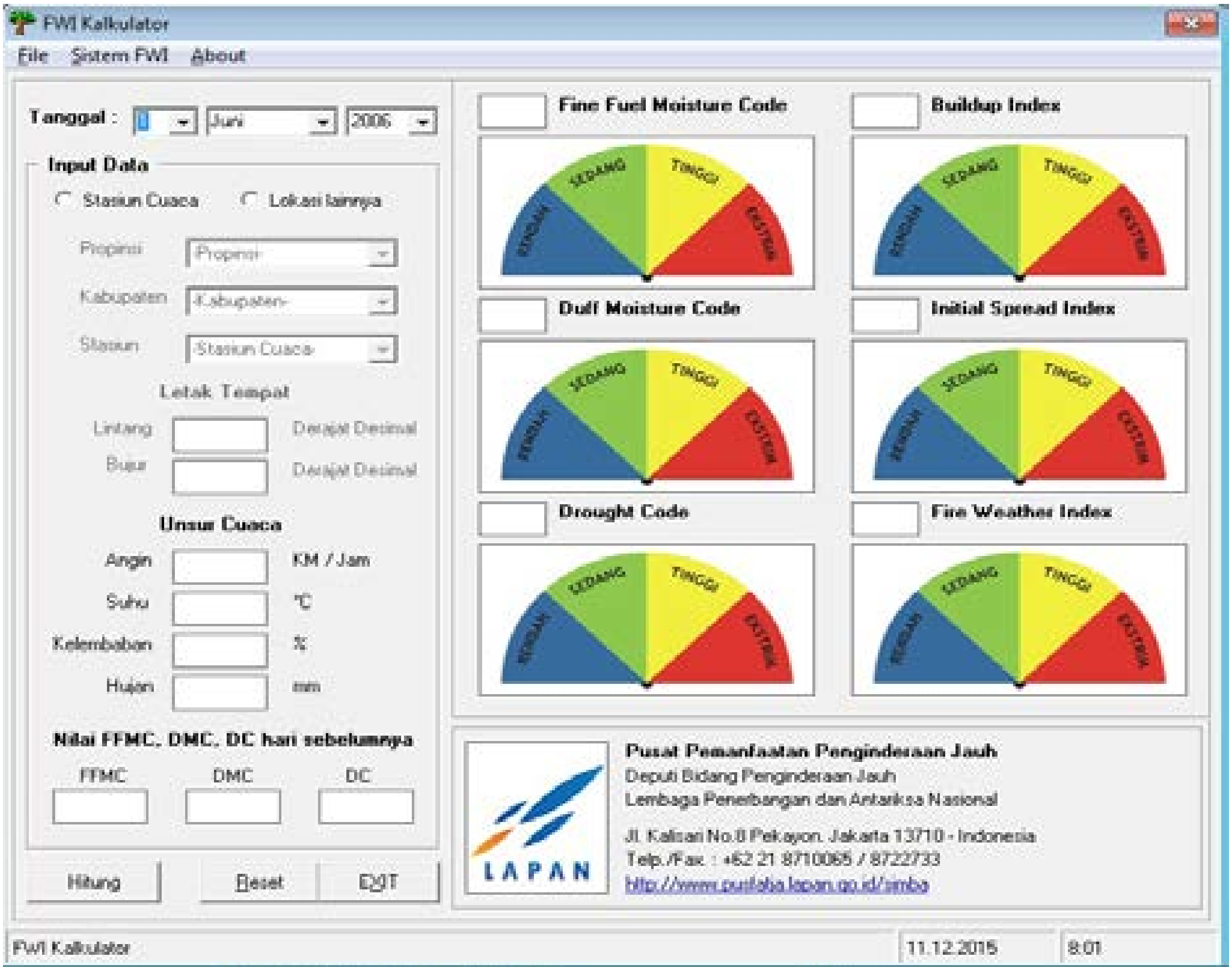
- The limited number of weather stations in Indonesia
- The sparse/uneven distributions of these weather stations
- The required Fire Danger Rating information on local scales (provincial/district scales) by the local government.

Thus, the use of satellite remote sensing data becomes the best alternative.

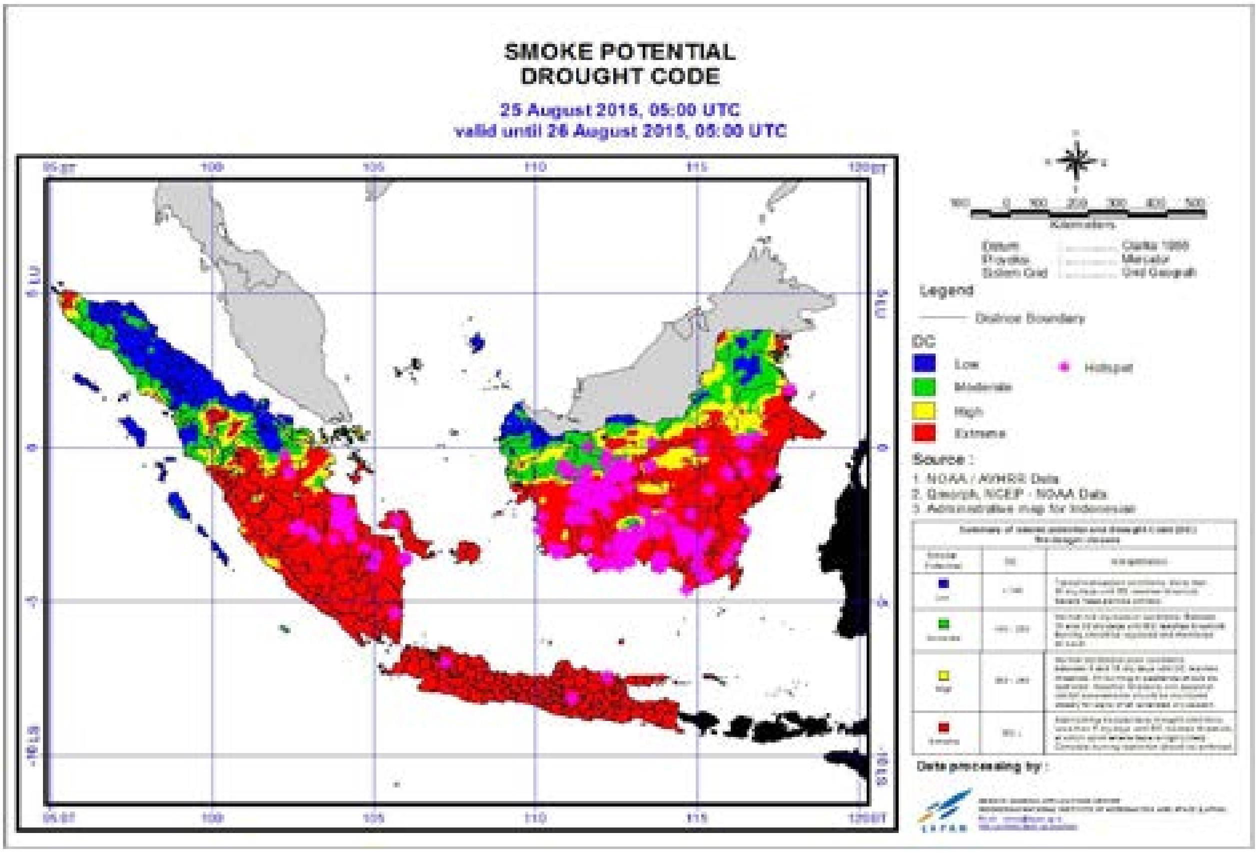
Remote sensing data has the advantage of providing comprehensive and multi-temporal coverage of large areas in real-time at frequent intervals. Remote sensing data of various resolution can be used to map and monitor forest fire in a cost effective way. Remote sensing based FDRS does not consider meteorological parameters directly, but the data processing is more complex and clouds often cover land observation.

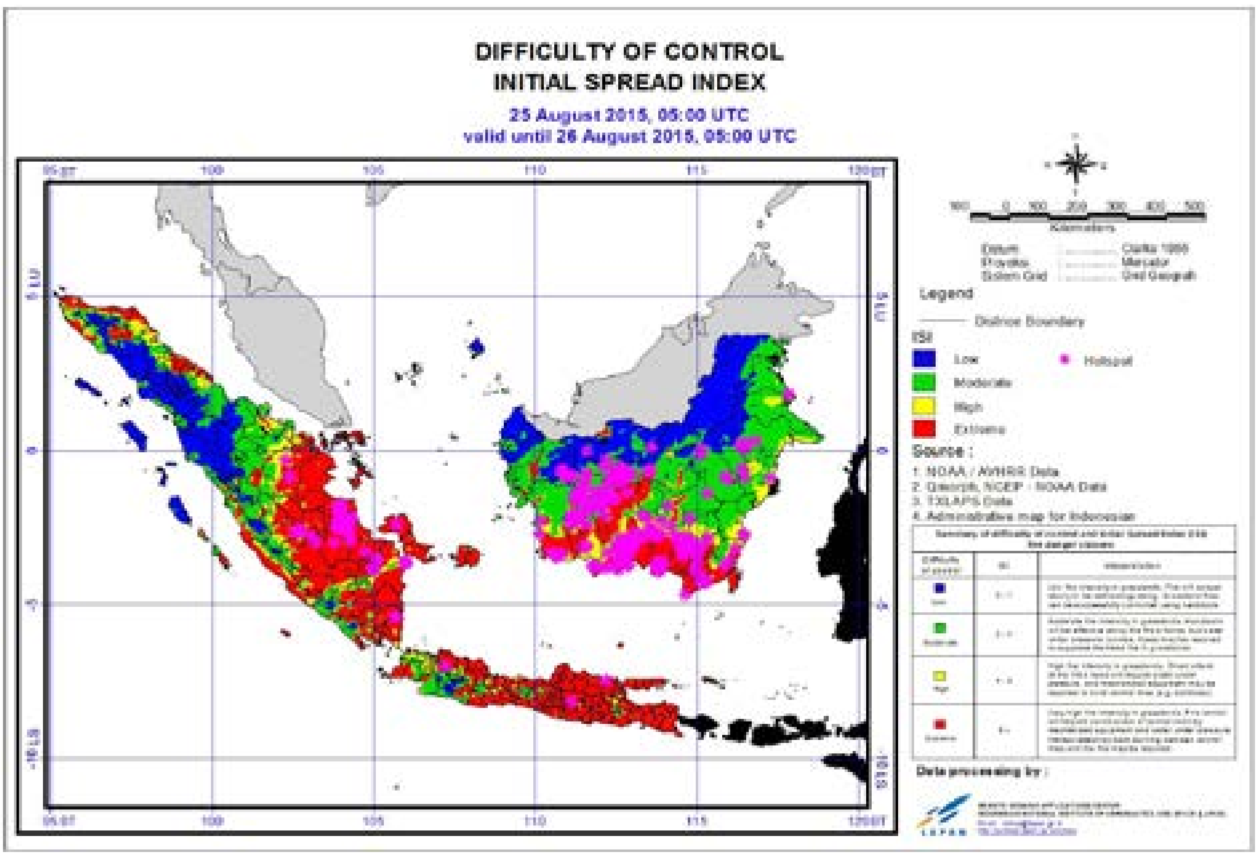
Khomarudin et al. (2005) tried to estimate the elements of meteorological for supporting the Indonesian FDRS using Moderate Resolution Imaging Spectroradiometer (MODIS) data and Noviar et al. (2005) attempted to operate the Indonesian FDRS using the National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR).

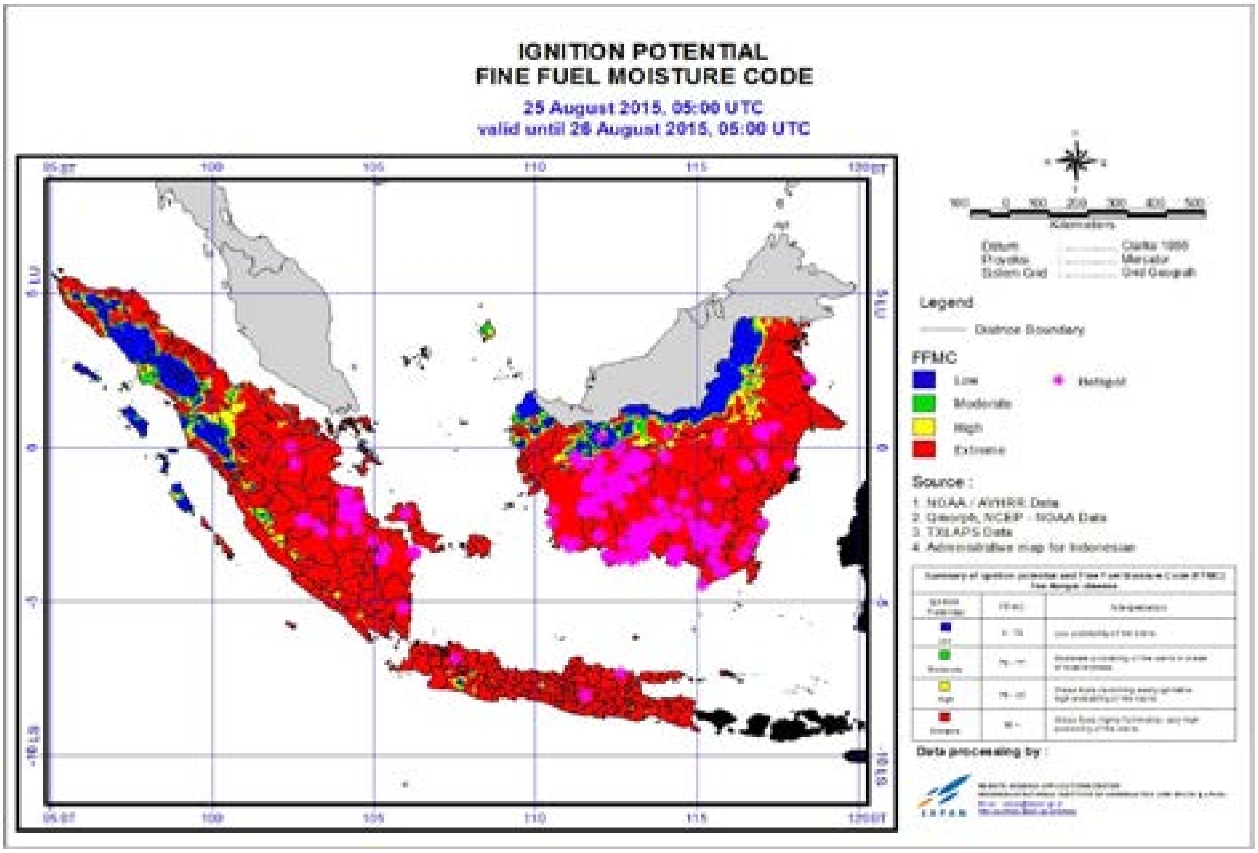
In order to implement the FWI system in local area, Indonesian National Institute of Aeronautics and Space (LAPAN) has built the FWI Calculator tool that can be easily run by anyone to calculate the value of the FDRS codes. Through inputing the coordinates of location and the value of meteorological parameters, one can obtain final FDRS values. For warning tool in the field, the FDRS dashboard can be placed in fire-prone areas such as peat lands, plantations and forests.

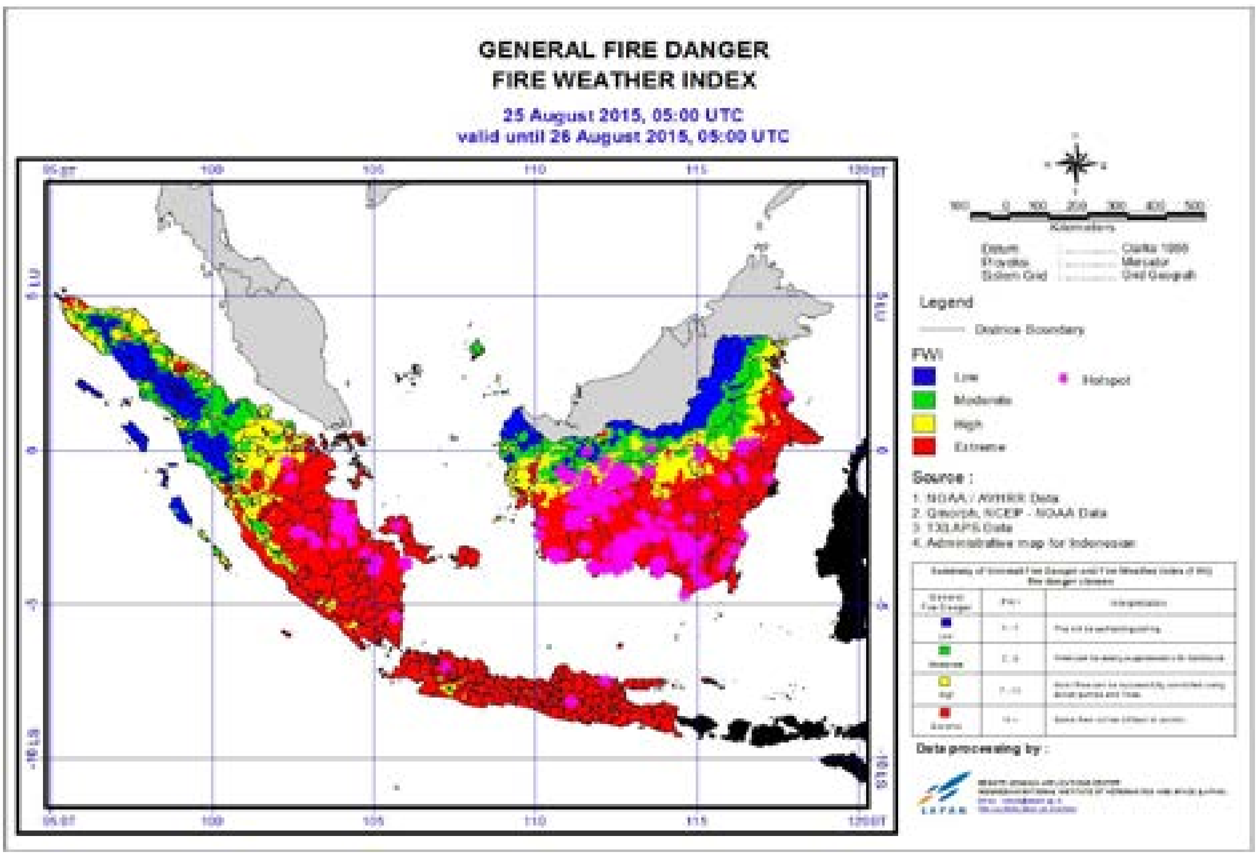


FWI Calculator for local area implementation and its dashboard in the field. Source: LAPAN


SMOKE POTENTIAL
DROUGHT CODE
25 August 2015, 05:00 UTC
valid until 26 August 2015, 05:00 UTC
Legend
District Boundary
DC
Low
Moderate
High
Extreme
Hotspot
Source :
1. NOAA / AVHRR Data
2. Qmorph, NCEP - NOAA Data
3. Administrative map for Indonesian
Data processing by :

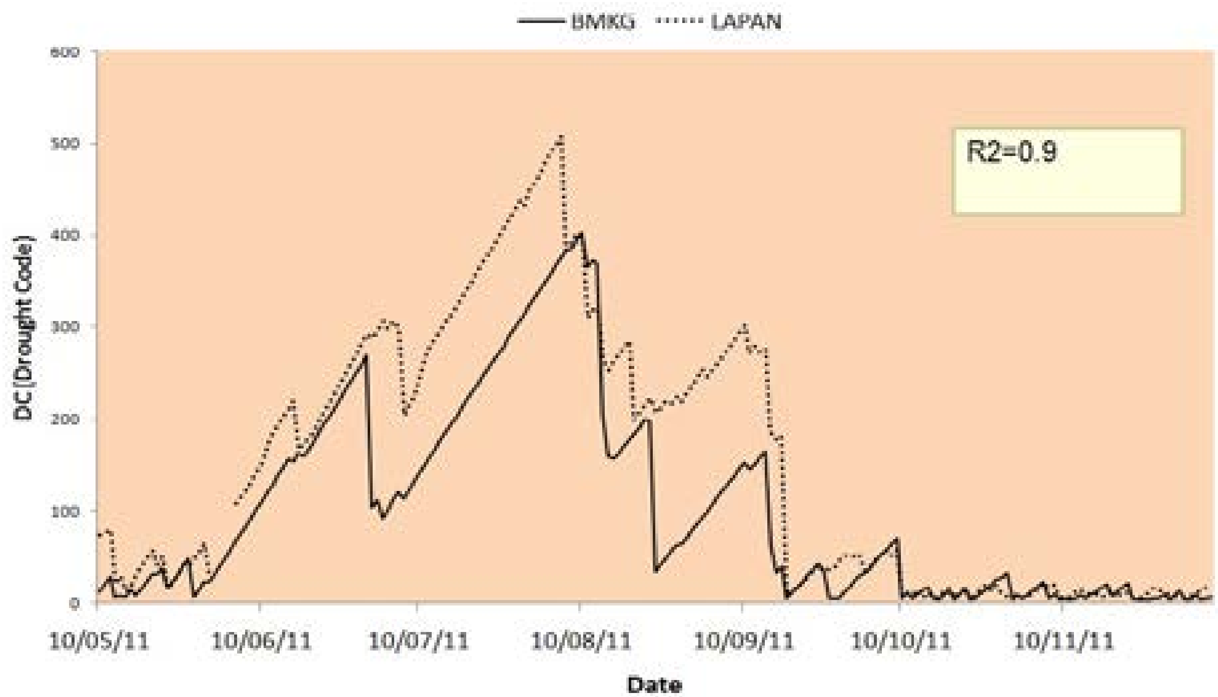

DIFFICULTY OF CONTROL
INITIAL SPREAD INDEX
25 August 2015, 05:00 UTC
valid until 26 August 2015, 05:00 UTC
Legend
District Boundary
ISI
Low
Moderate
High
Extreme
Hotspot
Source :
1. NOAA / AVHRR Data
2. Qmorph, NCEP - NOAA Data
3. TXLAPS Data
4. Administrative map for Indonesian
Data processing by :

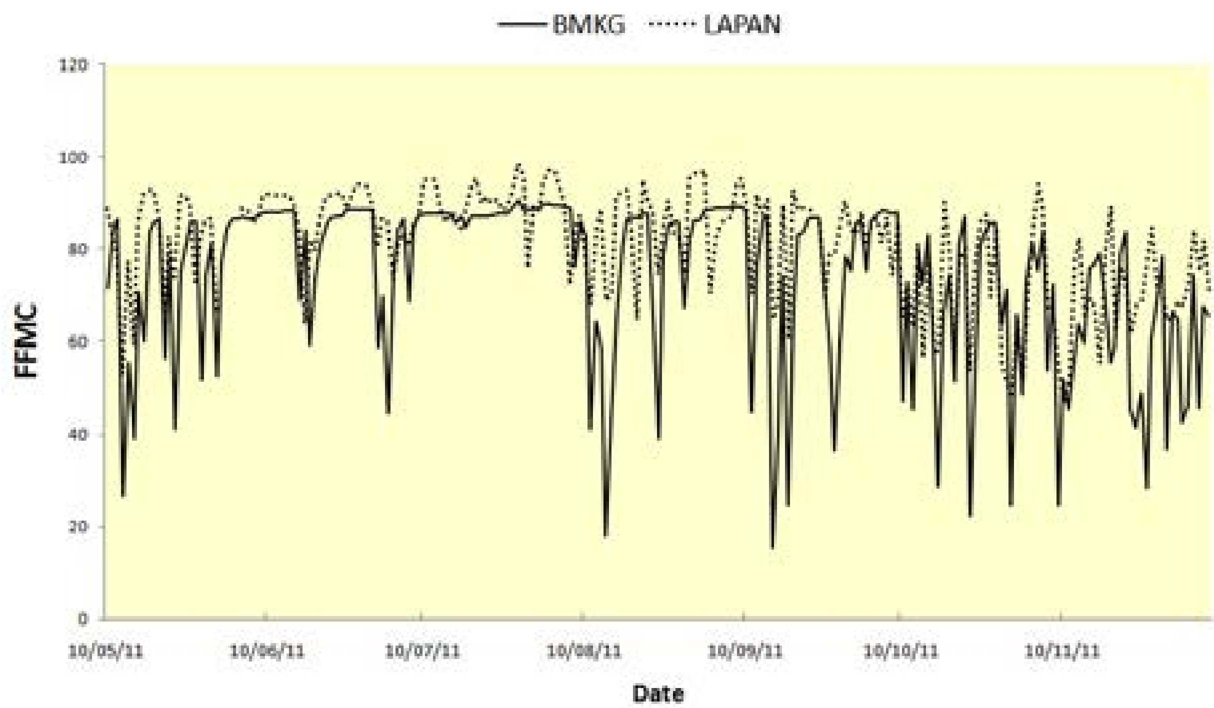




FDRS Codes generated from remote sensing data. Source: LAPAN

The comparison analysis between remote-sensed FDRS evaluation and FDRS generated from ground climatological station measurements by Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG) showed a good relationship.





DC and FFMC codes based on remote sensing data compared with measurement climatological based.

3. Fire Hotspot Monitoring

A variety of space-borne sensors are used to map fires on a global scale. Fire hotspots can be detected by using several remote sensing data, i.e., NOAA-AVHRR, European Space Agency (ESA) Along Track Scanning Radiometer (ATSR) and the National Aeronautics and Space Administration (NASA) MODIS.

Fire detection from satellite-based sensors is determined by sensor characteristics such as spectral bands, data processing chains, detection algorithms and revisit frequency. Fire detection also depends on fire regimes as these results in different spatial and temporal patterns of burning (Stolle et al., 2004).

Global active fire detection is performed using a hotspot algorithm based on the band information of mid and thermal infrared sensors from NOAA-AVHRR, ESA-ATSR and NASA-MODIS.

The fire hotspot algorithm of MODIS from Justice et al. (2002) is developed from heritage algorithms which are based on AVHRR and Tropical Rainfall Measuring Mission (TRMM) Visible and Infrared Scanner (VIRS). The algorithm uses brightness temperatures derived from the MODIS 4 and 11 µm channels, denoted by T4 and T11, respectively.

The MODIS instrument has two 4-µm channels, numbered 21 and 22, both of which are used by the detection algorithm. Channel 21 saturates at nearly 500 K; channel 22 saturates at 331 K. Since the low-saturation channel is less noisy and has a smaller quantization error, T4 is derived from this channel whenever possible. However, when channel 22 saturates, or has missing data, it is replaced with the high saturation channel to derive T4. T11 is computed from the 11-µm channel (channel 31), which saturates at approximately 400 K. The 250-m near-infrared band (0.86 µm), averaged to 1-km resolution, is also used to identify highly reflective surfaces those are more likely to cause false alarms. This reflectance is denoted by ρ2.

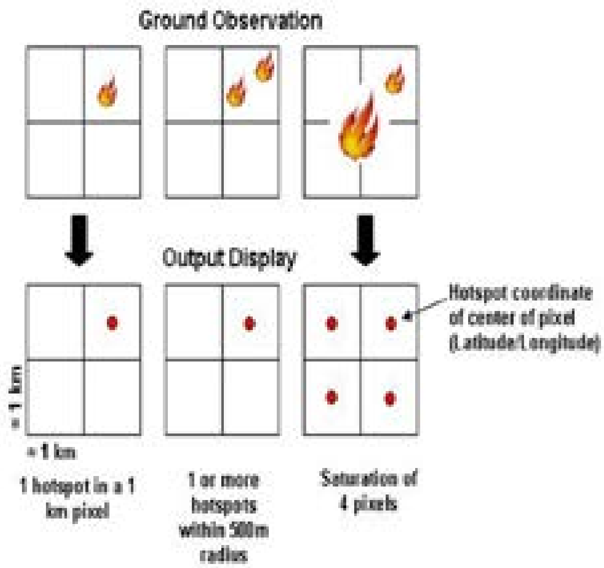


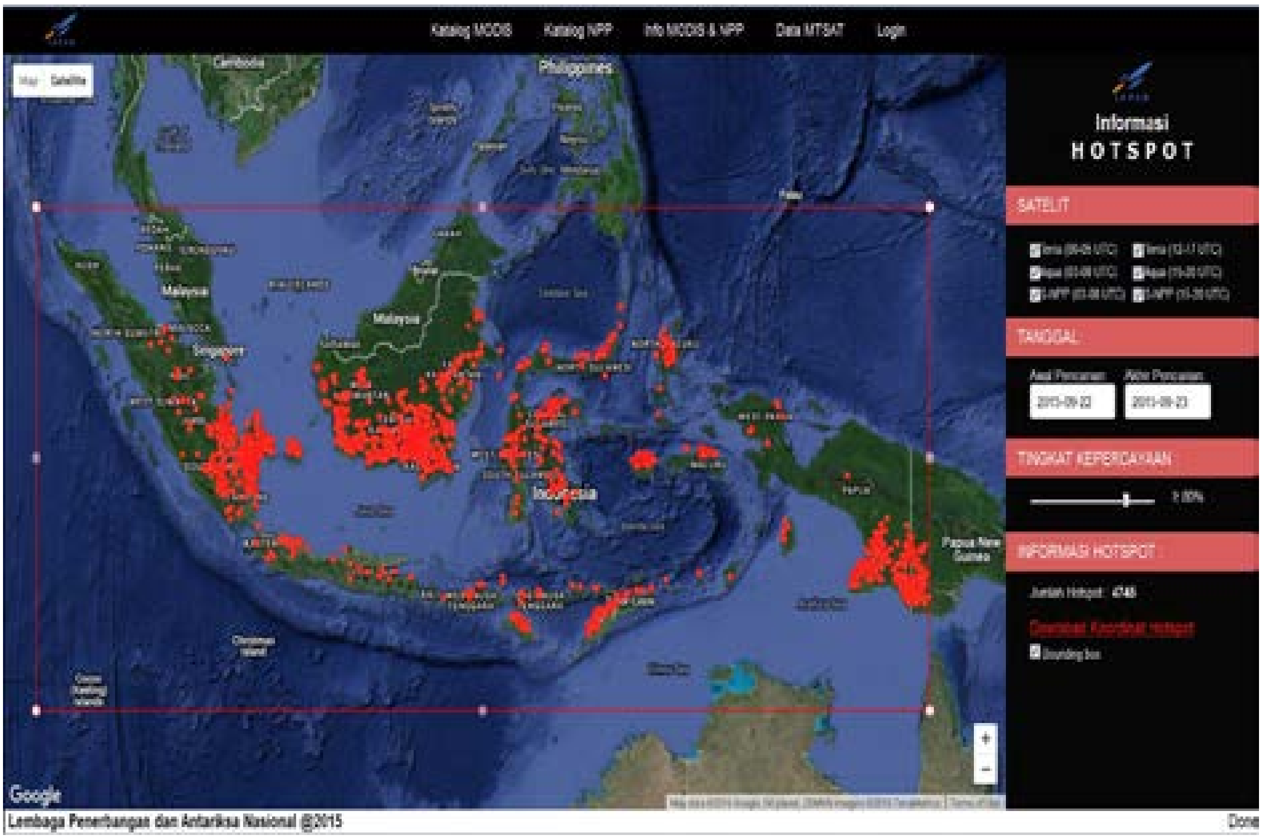
Illustration of how fire hotspots represent fire location in the field. Source: FIRMS

Stolle et al. (2004) attempted to verify the fire hotspot by using multisource satellite data. The AVHRR, ATSR, Defense Meteorological Satellite Program-Operational Linescan System (DMSP-OLS) and MODIS fire datasets for Indonesia were compared with each other and with burnscar maps derived from high spatial resolution data. Results show that each dataset detects different fires. More than two-thirds of the fires detected by one dataset are not detected by any other datasets. None of the datasets detect all fires in test areas. Fire datasets were not complementing each other as they all had commission as well as omission errors. The detection of fires is determined by fire regime, sensor characteristics and the fire detection algorithm used.

Several organisations provide fire hotspot information on their websites for free. The following are some web addresses that provide hotspot data:

Avalibility of Fire Hotspot data on market

Institution	Data Source	Web Address
LAPAN	MODIS, VIIRS	http://modis-catalog.lapan.go.id/
FIRMS NASA	MODIS	https://earthdata.nasa.gov/data/near-real-time-data/firms
GIC - AIT	MODIS	http://www.geoinfo.ait.ac.th/modis/
ASMC	NOAA/AVHRR	http://asmc.asean.org/home/



Daily fire hotspot information derived from MODIS and VIIRS in Indonesia on September 22-23, 2015. Image: LAPAN

Sentinel (online hotspot detection system), Australia

Sentinel is a national bushfire monitoring system that provides timely information about hotspots to emergency service managers across Australia. The mapping system allows users to identify fire locations with a potential risk to communities and property.This system was initially developed during the bushfires in New South Wales and the Australian Capital Territory in early 2002.

It utilizes satellites with thermal infra-red sensors to detect hotspots which indicate bushfires. The satellites pass over Australia each morning and afternoon, observing the land surface and beaming that information to Geoscience Australia's ground. The information is analysed automatically by a computer to detect hotspots. Within an hour of the satellite overpass the hotspots appear on the internet site. The system is functioning as a powerful online tool for bushfire mapping for Australian Government Geoscience Australia.

Sources:
http://www.ga.gov.au/ausgeonews/ausgeonews200906/fire.jsp
http://sentinel.ga.gov.au/#/announcement

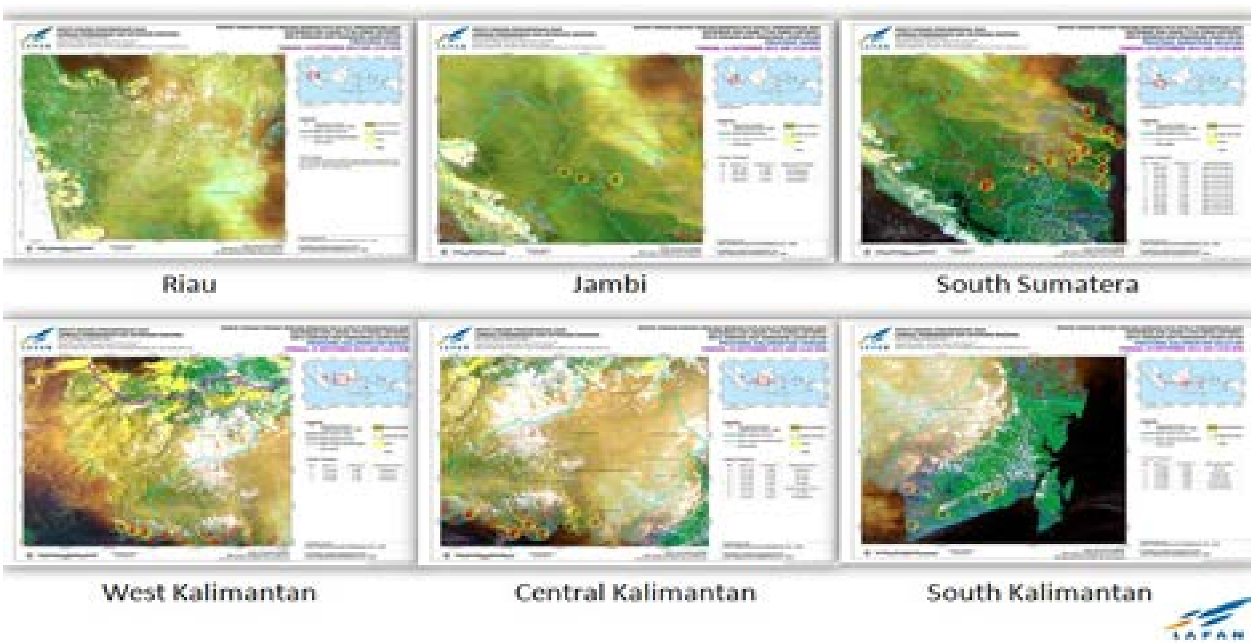
4. Smoke and Haze Monitoring

Atmospheric aerosols play a potentially important role in the Earth's climate system. They have direct interaction with solar and terrestrial radiation through scattering and absorption thereby modifying the Earth's radiation budget. Biomass burning is recognized as an important source of atmospheric pollution giving rise to the release of large quantities of gaseous emissions and particulate matter (Crutzen and Andreae, 1990). Each year, more than 100 million tons of smoke aerosols are released into the atmosphere from biomass burning, out of which 80% are in the tropical regions (Kharol and Badarinath, 2006). Smoke and haze are serious consequences of forest/ land fires in Indonesia and is arguably one of Indonesia's worst environmental problems.

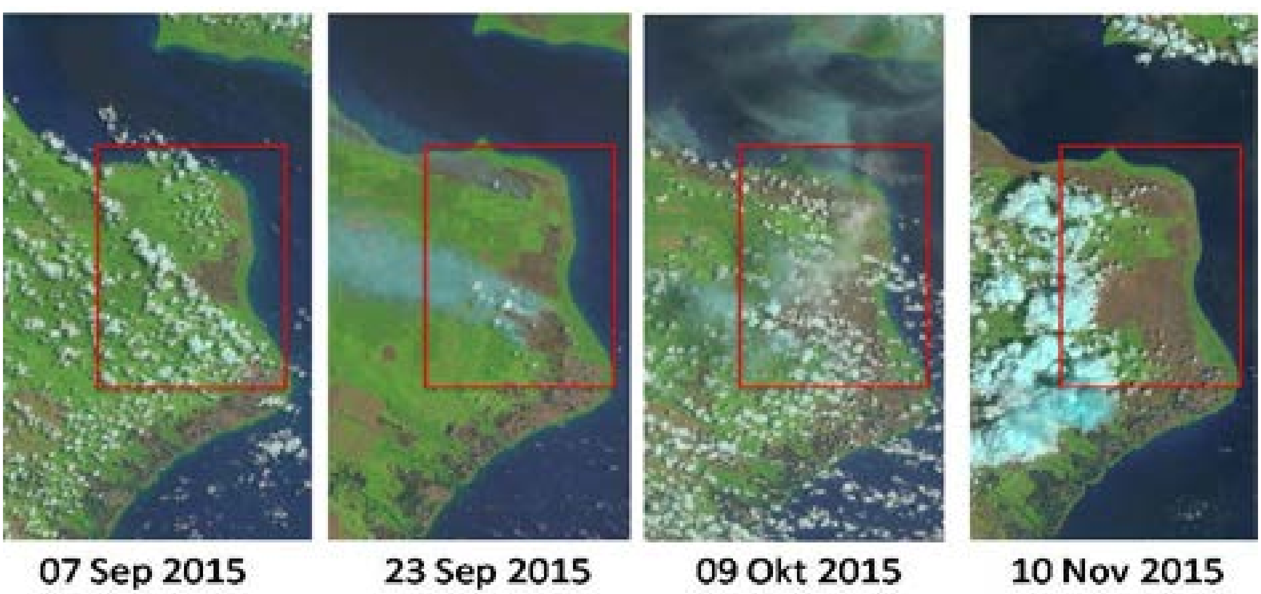
There are several methods that can be used for detection of smoke and haze. As a sample, based on AVHRR image, the analysis can be done using the normalized difference image calculated from the visible (channel 1; 0.58–0.68 mm) and thermal infrared (channel 4; 10.3–11.3 mm) channels.

A variety of high temporal resolution images can be used for daily monitoring the smoke and haze dispersion, such as, AVHRR, MODIS and Multi-angle Imaging Spectroradiometer (MISR). However, to acquire more detailed information regarding burnt landcover type, medium to high spatial resolution data is required. Landsat-8 has repeated acquisition for every 16 days with 30 m spatial resolution. The types of landcover which are burned can be identified using visual interpretation of such satellite images. The repetitive coverage also allows monitoring landcover changes before, during and after burning periods. For precise location of burned area, the SPOT-6/7 with a 1.5 m spatial resolution or other high resolution images, e.g., WorldView-1/2/3 can also be used. The visual interpretation of the burned area can be determined based on particular appearance depending on the usage of band information and smoke discharged from the land.

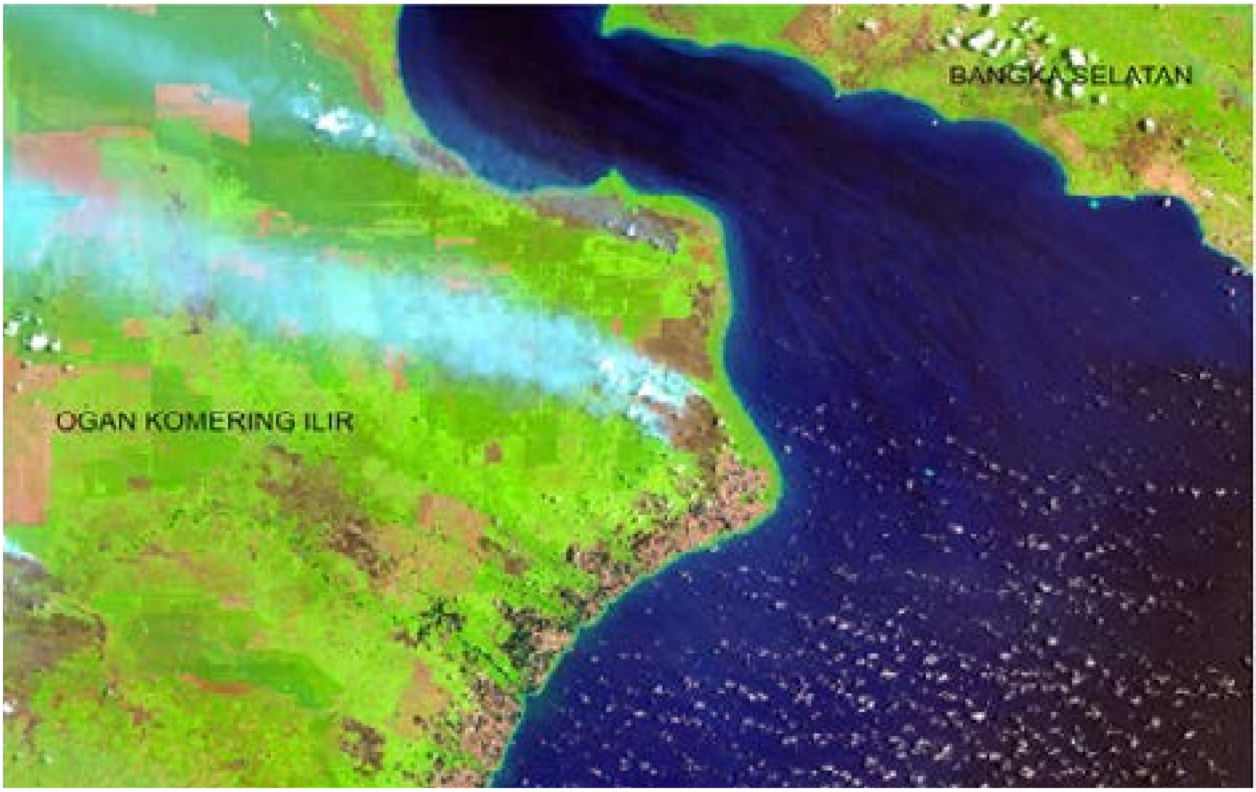
LAPAN has three ground station located in Parepare (South Sulawesi), Rumpin - Bogor (West Java) and Pekayon (Jakarta). Daily MODIS data, Landsat-8 data and SPOT-6/7 from the ground stations are received. The monitoring of smoke and haze is done by using MODIS data on daily basis by integrating the hotspot and red, green and blue (RGB) composite of smoke/haze from the MODIS data. LAPAN also complement the monitoring by using Landsat-8 data for every 16 days. During the fire seasons, LAPAN also acquire the SPOT-6/7 in order to map precise location of the burned area.



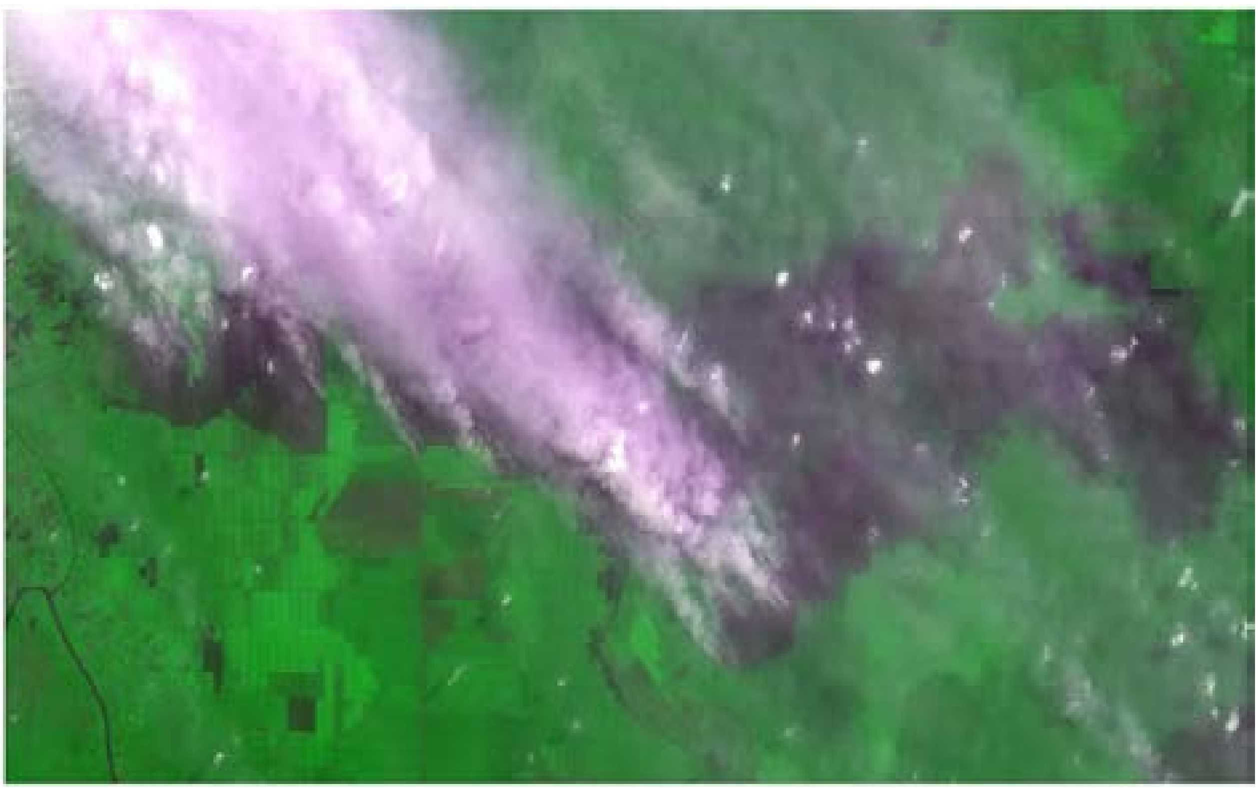
Fire hotspot and smoke haze distribution using MODIS data on September 23, 2015. Source: LAPAN



Multitemporal of Landsat-8 showing the changes before and after burning episodes in Ogan Komering Ilir, South Sumatera. Source: LAPAN



Smoke/haze from forest/land fire September 23, 2015 in South Sumatera detected from Landsat-8. Source: LAPAN



Smoke/haze from forest/land fire on September 17, 2015 in South Sumatera detected from SPOT-7. Source: LAPAN

5. Burned Area Mapping

Burned area mapping is performed to measure the total area affected by fires. Its purpose is to detect and describe the scars left by fires based on their spectral signature and/or fire-induced spectral changes.

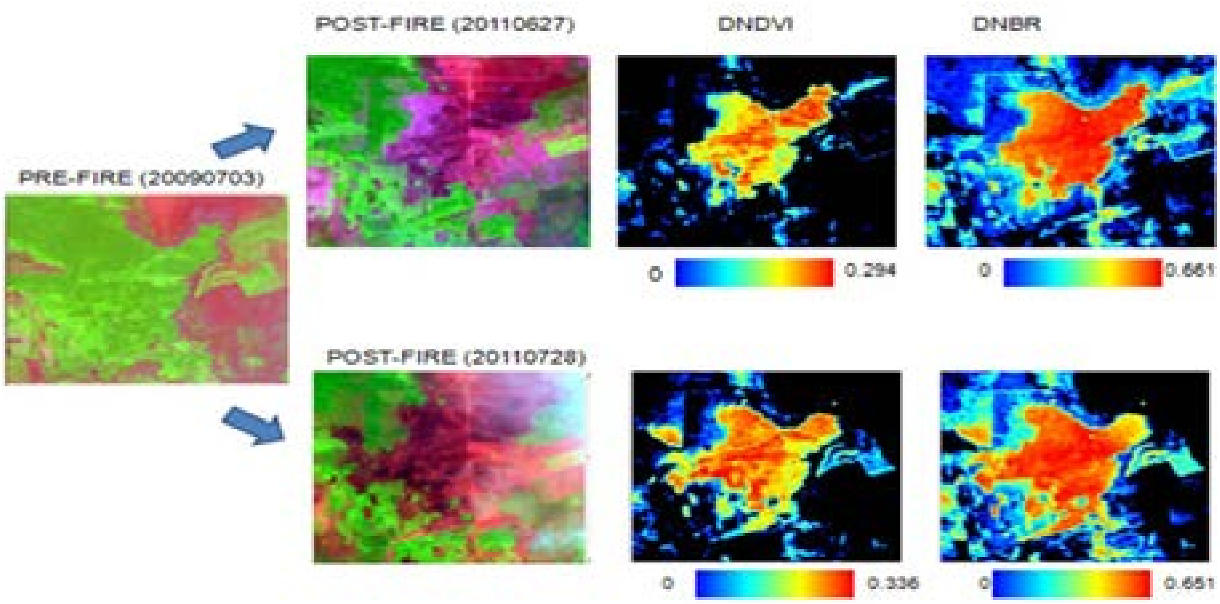
There is a wide variety of satellite data sources from optical and microwave instruments used to map the burned area. A variety of sensors can be used for mapping burned area, e.g., Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) aboard Landsat8 and the MODIS on board Terra/Aqua as well as high spatial resolution satellites such as WorldView-1/2/3, GF-2, Cartosat-1, Sentinel-1/2 etc. In general, coarse resolution sensors such as MODIS can cover extensive area of land every day. Therefore, it is suitable for the daily monitoring of burned area especially in very large fires. The MODIS data is useful for preliminary mapping of burned areas and it can be used as reference for further observation with high resolution images. By using mid to high resolution images, detailed information on burned landcover types can be obtained. Such information provides severity of burned areas of each landcover type and helps in prioritising rehabilitation measures.

The remote sensing methods dealing with scar mapping include: (i) difference of pre- and post-fires original bands or indices (Key and Benson, 1999; Loboda et al., 2007), (ii) thresholding of original bands or indices (Hall et al., 1980; Huesca et al., 2008; González-Alonso and Merino-de-Miguel, 2009), (iii) unsupervised or supervised classification of original bands or indices (Milne, 1986; Miller and Yool, 2002), (iv) spectral mixing analysis (Cochrane and Souza, 1998; González-Alonso et al., 2007), (v) time series analysis (Milne, 1986; Roy et al., 2002, 2005), etc. At regional to global scales, the detection of burned areas by means of satellite data has been traditionally carried out by AVHRR because of its high temporal resolution (Kaufman et al., 1990; Chuvieco et al., 2008). However, the MODIS sensor has opened up a new era in the remote sensing of burned areas (Justice et al., 2002; Roy et al., 2002, 2005). It has more than 30 narrow bands at wavelengths from the visible to the thermal infrared and at variable spatial resolutions (250–1000 m), which offers great potential for burned area mapping.

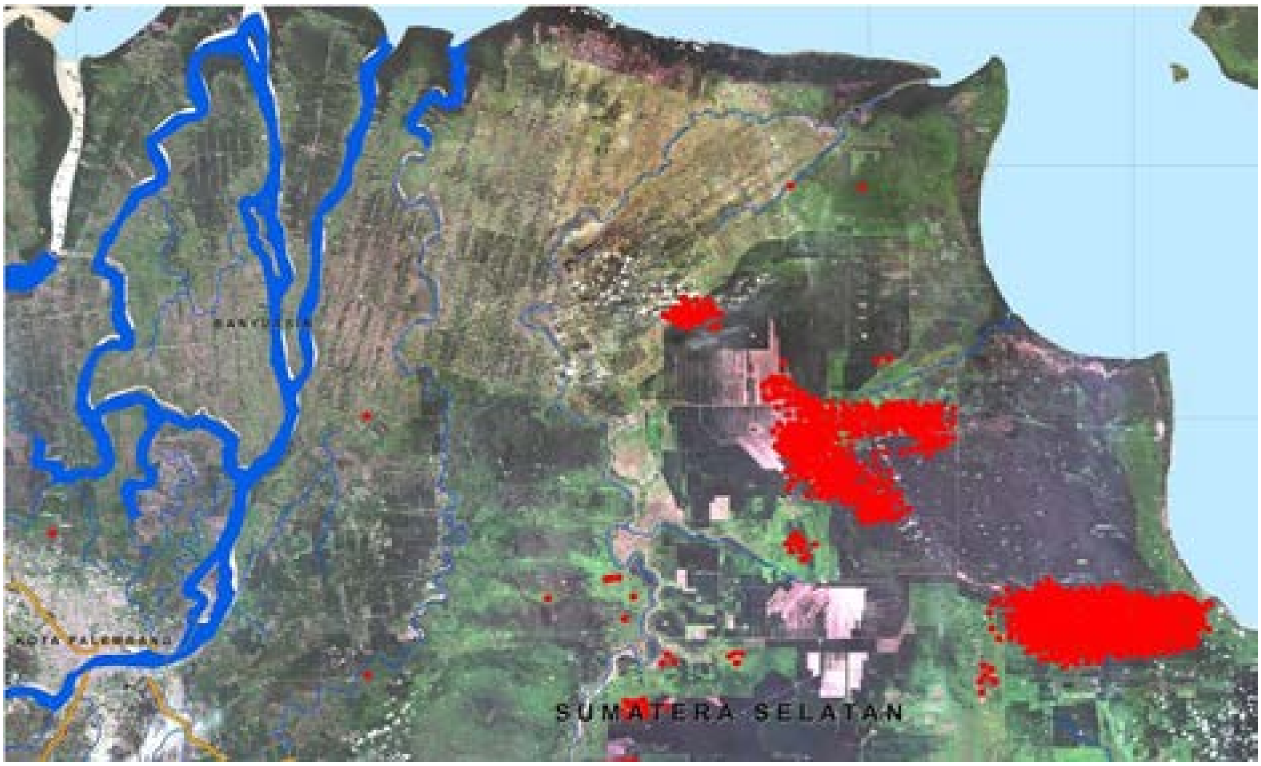
Among the different methods of burned area mapping by means of reflectance satellite

Fires in Kalimantan in September 2014, leave the burned area which cause environmental and land resources degradation. Image: LAPAN data, the ones using spectral indices are the most widespread. Vegetation indices (e.g. NDVI – Normalized Difference Vegetation Index), whose estimation typically involves data from the red and near-infrared (NIR) bands, have been commonly used to derive vegetation properties but also to discriminate and map burned areas. According to Lentile et al. (2006), burned vegetation results in a drastic reduction in NIR reflectance. This is typically accompanied by a rise in shortwave-infrared reflectance (SWIR). This is the case of the Normalized Burn Ratio (NBR) and the differenced NBR (dNBR), developed by Key and Benson (1999) and the MODIS Burned Area Index (BAI), developed by Martín et al. (2006).

In addition to the use of spectral indices, several studies have showed the utility of active fire detection for burned area mapping. In active fire detection, fire thermal energy, as measured by mid-infrared channels, is used to identify active fires. The scar mapping is developed based on examples in the total number of active fires (Pozo et al., 1997). However, the temporal and spatial patterns of biomass burning cannot be estimated reliably from active fire data, as the satellite may not overpass at the time of the fire, or the fire may be obscured due to cloud cover or dense smoke (Roy et al., 2002). This difficulty can be solved through the combination of active fire information together with spectral indices. Following this model, Roy et al. (1999) developed a multi-temporal burn scar detection algorithm using a time series of burn scar index data (based on a vegetation index) derived from AVHRR daily images, to compute a burn scar index change map that was then classified using thresholds based on the output of an active-fire detection algorithm. Fraser et al. (2000) also used AVHRR data to develop their hotspot and NDVI differencing synergy (HANDS) algorithm, an approach that combines the strengths of hotspot detection and NDVI differencing for boreal burned area mapping. Al-Rawi et al. (2001) tried to go beyond designing a system for monitoring the status of a fire in real time by creating a system that would also produce a near real-time burned area map. To do so, Al-Rawi et al. (2001) used NDVI – Maximum Value Composites as well as active fire locations, both derived from AVHRR data. Another approach taken by Pu et al. (2004) was an algorithm based on fire dynamics on a daily basis to obtain daily information on active fires and burned scars, using AVHRR data from California for NDVI calculation and hotspot detection.

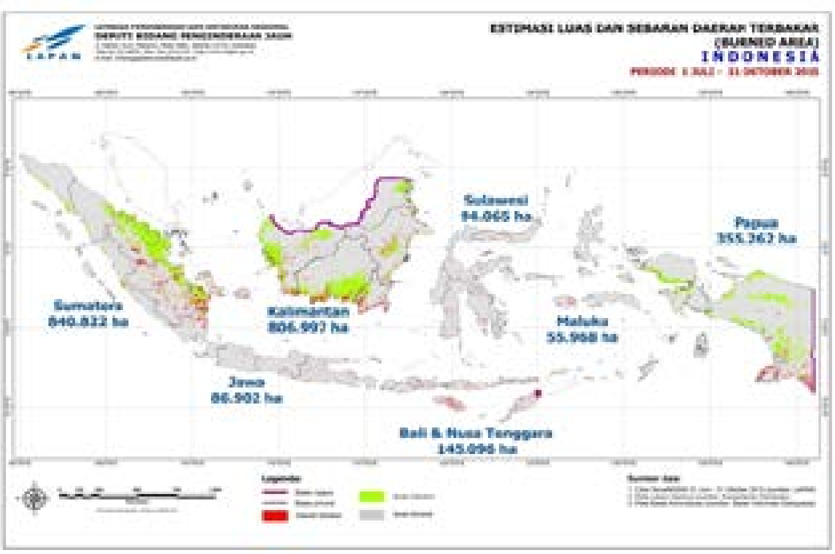


Burned area detection using dNDVI and dNBR of SPOT-4 images in Riau. Image: LAPAN



Density of Hotspot (October 21-27, 2015) zooming on SPOT6/7 mosaic 2014-2015 – OKI South Sumatera

Burned Area Mapping
(Indonesia, MODIS, 1 July – 31 Oct 2015)



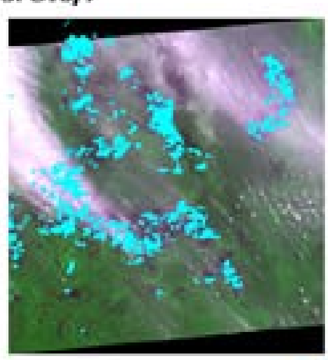
Method:

$$NBR_s = \frac{\rho NIR - \rho SSWIR}{\rho NIR + \rho SSWIR}$$

dNBR = NBRpre - NBRpost

10 days MODIS Terra

Statistic Accuration: 75 – 85 %
Validation with:
Landsat-8,
SPOT6/7



6. Information Dissemination

The results of remote sensing data processing for forest/land fires monitoring and mapping can be distributed to users through a web based geographic information system (WebGIS). This system is interactive, where users can select different types of information and date, zoom in/out locations, measure distance and provide markers. Users also have the option to print or download the information.

The information dissemination system built by LAPAN displays a selection of daily fire hotspots, forest fire danger rating system, as well as information of the burned area. Users can easily access the information. The website of the system is as below.

http://pusfatja.lapan.go.id/simba

In case of emergency response, LAPAN disseminate the information to the national disaster management agency (Badan Nasional Penanggulangan Bencana, BNPB) and other stakeholders on a daily basis via applications on mobile phones and emails. The key users are the local BNPB groups that work on the frontline to fight the fire and stakeholders in central government, including BNPB, that provides directions and in time report. Users can zoom in and zoom out the product information on their mobile phones.

Information is delivered to the public via newspaper (printed or online media), press conference with the BNPB and TV interviews. The users should be aware of limitations of the information derived from satellite remote sensing data on forest/land fires. It may so happen that the hotspot is not always the forest/land fire. It is only an indication of location that has higher temperature than its surroundings. Further, hotspots could not be detected if the satellite does not pass the area or if the area is covered by clouds or thick haze. The user should also notice that the burned area cannot be estimated by summing the amount of hotspots, but it should be done by following the standard procedure and techniques to generate measurable, reportable, verifiable data and information. The standardized methodology is useful in determining burned area comparison on periodical basis.

Emerging tools

Cloud based platform services open up a new era for disaster management and information dissemination. Tomnod, a crowdsourcing platform developed by DigitalGlobe, uses geospatial databases and collect inputs from crowd to help in disaster management and disaster risk reduction. Once a disaster happened, the Tomnod program will make massive remote sensing data available and activate the crowdsourcing platform to allow everyone around the world to tag visible damage of that area on near real-time satellite images and deliver the information to help emergency response policy making.

Example: On April 25, 2015, Nepal experienced a 7.8 magnitude earthquake. DigitalGlobe activated a Tomnod crowdsourcing campaign to catalogue the extent of the damage.

Such crowdsourcing platforms have great potential of mapping fire hotspots and burned areas.

Sources:
http://www.digitalglobeblog.com/2013/11/22/typhooninsight/
http://emergencyjournalism.net/featured-tool-tomnod/

7. Technical Assistance Meeting

In accordance with the mandate of Space Law Number 21 Year 2013, remote sensing data processing must be done with reference to the method and the quality established by LAPAN. LAPAN has a task for giving supervision to other local and central institutions in how to process and analyze the remote sensing data for such applications. Related to forest/ land fire, LAPAN had conducted some trainings in remote sensing application for burned area mapping, calculating the forest danger rating system, and also how to interpret the hotspot data. By now, LAPAN have conducted technical assistance meeting with following agencies: the Plantation Directorate of Ministry of Agriculture of West Kalimantan, Forestry Directorate of Central Kalimantan Province, Local Disaster Management Body of South Kalimantan, Forestry Directorate of Riau and South Sumatera Province and also Plantation Directorate of Ministry of Agriculture of Jambi.

Technical assistance meeting developed by LAPAN and user agencies.
Image: LAPAN

8. Conclusion

Peat land fires have reoccurred every year in Indonesia. The severe ones were during El Niño events in 1982, 1997 and 2015. It has caused many serious problems to health, transportation, education and accounts for high emissions of greenhouse gases that may affect global warming.

Space-based information and technologies are one of the most powerful tools to support the full cycle of forest/land fire management such as documenting fire prone areas, providing early warning, emergency response and post fire assessment. In Indonesia, remote sensing data offered efficient alternatives for building up the FDRS, especially in the regions with limited weather stations. The advantages of remote sensing data are distinctive in fire monitoring and haze/smoke detection. For example, the frequent revisit interval and extensive coverage of remote sensing data provide possibilities of near real-time monitoring of fires and enhance early warning. As to post-fire ecosystem restoration, remote sensing data is capable of mapping burned areas, estimating vegetation conditions and monitoring the post-fire forest patterns and changes over time. All these efforts will facilitate to mitigate impacts and occurrences of forest/land fires.

Institutional efforts are essential as well for implementing space-based technologies in forest/land fires management. Based on the experience from Indonesia, implementation of these tasks on an operational basis requires awareness raising among the user community, public participation and appropriate legislation framework. Advanced technologies combined with local community-based forest/land fire management makes usage of space-based information to the fullest extent. WebGIS based and cloud based platforms are effective in disseminating information to wide range of users. Early warning messages can be issued in local areas through web and communication devices during dry season.

Incorporating space-based information and technologies in forest/land fire management strengthens the capabilities of disaster management authorities. It provides scientific basis for devising appropriate policies and contingency plans to mitigate and respond to the forest/land fire disasters.

Image: merdeka.com

This document is aimed to showcase the application of remote sensing technologies in the forest/land fires management in Indonesia. We hope it provides ready reference to the practitioners involved in forest fire monitoring.

About UN-SPIDER Regional Support Office in Indonesia

http://www.un-spider.org/network/regional-support-offices/indonesia-regional-support-office

A Regional Support Office (RSO) is a regional or national centre of expertise that is set up within an existing entity by a Member State or group of Member States that have put forward an offer to set up and fund the proposed RSO. An RSO can be hosted by a space agency, a research center, a university, or a disaster management institution, to name some examples. These offices communicate and coordinate with UN-SPIDER on a regular basis, covering the realms of Outreach and Capacity building, as well as Horizontal Cooperation and Technical Advisory Support.

The UN-SPIDER Regional Support Office (RSO) in Indonesia is hosted by the Indonesian National Institute of Aeronautics and Space (LAPAN). The RSO established in 2013 under a cooperation agreement between LAPAN and the United Nations Office for Outer Space Affairs (UNOOSA) during The fiftieth session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space that was held on 11 -22 February 2013 at the United Nation Office at Vienna, Austria. In the national level, LAPAN has legal authorize from President of Republic of Indonesia as the national space agency which listed in INPRES No. 6/2012 on the Provision, Use, Quality Control, Processing and Distribution of High Resolution Remote Sensing Satellite Data. In order to support disaster information using remote sensing satellite data, LAPAN coordinates with the Indonesian National Board for Disaster Management (BNPB). LAPAN have implemented several projects in the field of disaster management and emergency response such as flood, drought, fire hotspot, and climate monitoring or prediction, as well as the assessment of those disasters and emergency response for other catastrophes such as tsunami, earthquake, volcanic eruption, etc. As an RSO, LAPAN provides experts for UN-SPIDER's technical advisory support to countries within the region and to contribute to capacity building efforts in the region.

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